imaging the surface; and

classifying each of the defects as being in one of a predetermined number of invariant core classes of defects.

37 63. An apparatus for classifying defects on the surface of an article, comprising:

an imager to produce an image of the defect and a reference image;

a storage device to store the defect image and the reference image;

a comparator to compare the defect image and the reference image; and

a processor to classify the defect as being in one of a predetermined number of invariant core classes of defects.- -

REMARKS

Claims 1-3, 6-20, 23-38 and 40-63 are pending in the application. Claims 6, 23, 41and 46 have been amended. Claims 9-17, 26-34 and 49-60 have been withdrawn from consideration. Claims 61-63 have been added.

Claims 1-3, 6-8, 18-20, 23-25, 37, 38 and 40-42 were rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent 5,801,965 (Takagi) in view of U.S. Patent 5,814,829 (Broude) and further in view of U.S. Patent 4,849,901 (Shimizu). Claims 35, 36 and 43-45 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Takagi, Broude and Shimizu and further in view of U.S. Patent 5,591,971 (Shahar). Claims 46 and 47 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Takagi in view of Shahar. Claim 48 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Takagi and Shahar and further in view of U.S. Patent 5,960,106 (Tsuchiya). These rejections are respectfully traversed. Applicants

respectfully request reconsideration and allowance of the claims in view of the following arguments.

The present invention relates to a method and apparatus for automatically classifying a defect on the surface of a semiconductor wafer into one of a plurality of invariant (i.e., standardized) core classes after inspection with, for example, a scanning electron microscope (SEM) and/or an optical inspection tool. The invariant core classes of defects can include a missing pattern on the surface, an extra pattern on the surface, a deformed pattern on the surface, a particle on the surface, a particle embedded in the surface, a particle and a deformed pattern on the surface, or craters and microscratches on the surface. The defect may be further classified into one or more subclasses of one of the invariant core classes, the subclasses being of arbitrarily defined defects defined by the user or preprogrammed in the apparatus. As the defects are classified, counts are maintained of the number of occurrences of each type of defect, and an alarm is raised if the defect count in a particular class exceeds a predetermined level.

Defects are accurately and reliably classified and monitored using the present apparatus and methodology, thereby enabling early detection and cure of processing problems. All defects are classified by the present methodology into one of a predetermined number of invariant core classes. The present invention thereby provides a standardized set of defect classes, which are readily correlated to the causes of defects. Moreover, since the defect classes are standardized rather than user-specific, the present apparatus and methodology requires a lesser number of defect images to be obtained for each defect class prior to becoming operational. Consequently, the present invention can be easily utilized during start-up and ramp-up of a production line.

Regarding the obviousness rejection of independent claims 1, 18, and 37 based on Tagaki, Broude and Shimizu, none of these references teaches or suggests classifying each

detected defect into one of a predetermined number of invariant core classes, as required by claims 1, 18 and 37. A sample invariant classification scheme according to the present invention is illustrated at Fig. 1 of the application, showing seven invariant core classes 3A-3E, into which all defects are classified. As discussed above, this invariant classification scheme is an important feature of the present invention because it enables standardization of defect classification, resulting in ready determination of the causes of defects compared to prior art inspection techniques, and the ability to use the present invention upon start-up and ramp-up of production.

It is contended in the Office Action that Tagaki teaches classifying defects into invariant core classes, as claimed. However, this is not an accurate characterization of Tagaki's teaching. As explained at col. 12:3-26 of Tagaki, its defect classes are changed (i.e., the number of classes are expanded) depending on how the defects fit into a constantly evolving classification model. If a defect falls outside or in between "clusters" in the classification space of Tagaki's classification model, a new cluster is made, and/or the operator is asked to classify the defect. Thus, Tagaki's classification scheme is the opposite of the claimed invariant classification technique. It is infinitely variable, allowing a new category to be made for each defect, if necessary. Tagaki is analogous to the prior art defect classification schemes, discussed at pages 2-3 of the present application, which lack standardized defect classes. In contrast, the claimed invention classifies each defect into one of a very limited number of invariant core classes.

Since none of the cited references teaches or suggests the step of classifying each defect into one of a predetermined number of invariant core classes, as required by independent claims 1 and 18, or teaches or suggests independent claim 37's processor for performing this step, no combination of the references, however made, could yield the invention of claims 1, 18 or 37,

and it would not have been obvious to modify any Tagaki/Broude/Shimizu combination to yield the claimed invention.

Moreover, even assuming, ***arguendo***, that the references taught all the recited features of claims 1, 18 and 37, it would not have been obvious to combine Tagaki and Broude as the Examiner suggests. It is contended in the Office Action that it would have been obvious to combine Takagi's defect inspection and classification technique with Broude's teaching of inspecting for defects, mapping and counting the defects and generating a signal when a threshold number of defects of a particular size and/or at a particular location are found, to thereby yield the invention of claims 1, 18 and 37.

Applicants disagree. The Examiner has not provided an objective teaching in either reference that would have motivated a skilled artisan to incorporate Broude's teaching into Takagi's system, because none exists. The purpose of Takagi's semiconductor device defect classification system is to extract feature data of the defects based on their classification, feed back this information to improve the automatic inspection process, use this information to determine the cause of the defects, and control the manufacturing machinery accordingly, to avoid further defects and improve yield. These functions are explained in Takagi at, for example, col. 5, line 27 to col. 6, line 9 with reference to Fig. 1.

Broude relates to a photolithographic mask (or "reticle") inspection system wherein when a threshold number of reticle defects of a particular size at a particular location is exceeded, the inspection is interrupted and the operator informed, so that time is not wasted continuing inspection of a low-quality reticle (see, e.g., col. 5, lines 47-67). In other words, Broude's system is for efficiently discovering and rejecting reticles that do not meet predetermined quality standards.

Tagaki's purposes would not be furthered by Broude's defect counting and signaling technique. Broude's approach to inspection is much different (and more primitive) than Tagaki's, and is used in a different context. Broude's technique is for inspecting completed masks before they are used in production to weed out low-quality masks (i.e., a "go -no go" test). In contrast, Tagaki improves product yield during production by using defect feature data from the inspection process to improve its inspection process, to determine the cause of the defects, and to adjust the operating parameters of its manufacturing machinery to prevent further defects. None of these functions are performed by Broude's inspection methodology, and none of Tagaki's goals would be served by modifying it with Broude's defect counting and display/inspection shutdown technique. Moreover, there is no objective teaching in Tagaki's yield improvement methodology relating to Broude's functions of defect counting resulting in inspection shutdown, or vice versa. Therefore, a skilled artisan would not have been motivated to add Broude's defect counting and display/inspection shutdown technique to Tagaki's inspection system to yield the invention of independent claims 1, 18 and 37.

It is contended by the Examiner that a skilled artisan would have been motivated to incorporate Broude's counting and display/shutdown features into Tagaki's inspection system to generate a signal to stop the process to get a better yield (see page 4). However, there is no support in either reference for this contention. As discussed above, Broude teaches counting defects, displaying the results and shutting down the inspection process to reject a low-quality reticle, not to improve the yield of the reticle manufacturing process (or of any other manufacturing process). Broude's process is not used for in-process inspection, where yield is an issue, but rather is used after completion of a reticle and before production using the reticle begins.

Moreover, stopping or slowing down the process to improve yield is not taught or even suggested as a desirable action in Tagaki. Rather, Tagaki arguably teaches away from such action by teaching the use of its inspection results to determine the causes of defects and to adjust the production parameters accordingly, thereby improving yield. Furthermore, Takagi teaches selecting and segregating defective products for repair by an automatic or manual "repair unit" (see col. 6, lines 39-59). Takagi's production line does not need to be slowed or stopped, as suggested in the Office Action, since Tagaki teaches an alternative technique for dealing with defective products. Such action would defeat the purpose of Tagaki's automated inspection/repair/process control system. It is well-established that if a proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification. ***In re Gordon***, 733 F.2d 900 (Fed.Cir. 1984); ***In re Ratti***, 270 F.2d 810 (CCPA 1959)(If a proposed modification or combination would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims prima facie obvious); MPEP § 2143.01.

The Examiner is using improper hindsight here, using the Applicants' disclosure (of their motivation for making the invention) against them. There is no objective teaching in the art offered in support of the Office Actions' stated motivation to combine the Takagi and Broude references. Furthermore, the newly cited Shimizu reference does not furnish any such objective teaching either. Indeed, it is not even alleged in the Office Action that Shimizu furnishes such a teaching. Thus, the statement in the Office Action offered to show motivation to combine Tagaki and Broude with Shimizu to yield the claimed invention is speculative, and cannot support a rejection under 35 U.S.C. § 103.

Consequently, independent claims 1, 18 and 37 are patentable, as are claims 2, 3, 6, 7, 8, 18-20, 23-25, 37, 38 and 40-42, which depend from claims 1, 18 and 37.

Further regarding dependent claims 6, 23 and 41, these claims have been amended for clarity to recite that the variant subclasses are subclasses of at least one of the invariant core classes. This amendment is supported, for example, at page 4, lines 12-14 of the application. None of the cited references teaches or suggests the recited feature of claims 6, 23 and 41 of further classifying one of the defects into a variant subclass. It is contended in the Office Action that Takagi teaches this feature; however, the cited passage of Takagi does not provide support for this contention. This passage relates to linking a defect class with a cause, not to further classifying defects that have been classified into subclasses of a particular class, as claimed. Consequently, claims 6, 23 and 41 are further and separately patentable.

Regarding the obviousness rejection of dependent claims 35, 36 and 43-45 based on Tagaki, Broude, Shimizu and Shahar, the Shahar reference does not furnish the necessary motivation to combine Tagaki, Broude and Shimizu to yield the computer readable medium of independent claim 18, from which claims 35 and 36 depend, or the apparatus of independent claim 37, from which claims 43-45 depend.

Consequently, claims 35, 36 and 43-45 are patentable.

Regarding the rejection of independent claim 46 based on Tagaki and Shahar, neither cited reference teaches or suggests the important step of classifying each defect into one invariant core class, as recited in amended claim 46. Furthermore, neither reference teaches or suggests the claimed step of imaging with both an SEM and an optical imager. Takagi teaches optical imaging only, and does not mention SEM imaging or the claimed combination of SEM and optical imaging. See Tagaki col. 15, line 15 et seq. Shahar teaches SEM imaging only.

Applicants note that Shahar's detectors 240, 250 are explicitly described as electron detectors, not optical detectors as contended in the Office Action. Since neither reference teaches or suggests the above-discussed SEM/optical imaging step of claim 46, any combination of Tagaki and Shahar, however made, would still be missing this step. Moreover, it would not have been obvious to add this step to any Tagaki/Shahar combination. There is no objective teaching offered to support the contention in the Office Action that a skilled artisan would have been motivated to add an SEM to Takagi's apparatus to obtain a better perspective of the image. This contention is speculative and cannot support an obviousness rejection.

Consequently, claim 46 is patentable, as is claim 47, which depends from claim 46.

Regarding the obviousness rejection of dependent claim 48 based on Tagaki, Shahar and Tsuchiya, the Tsuchiya reference does not furnish a teaching or suggestion of the important step of imaging with both an SEM and an optical imager of independent claim 46, from which claim 48 depends, missing from Tagaki and Shahar. Thus, any combination of Tagaki, Shahar and Tsuchiya, however made, would still be missing this step, and it would not have been obvious to add this step to any Tagaki/Shahar/Tsuchiya combination.

Consequently, claim 48 is patentable.

Reconsideration and withdrawal of the rejection of claims 1-3, 6-8, 18-20, 23-25, 35-38 and 40-48 under 35 U.S.C. §103(a) are respectfully requested.

Regarding new independent claims 61-63, these claims are patentable over the cited references because the references do not, alone or in combination, teach or suggest classifying each defect into one of a predetermined number of invariant core classes, as recited in these claims.

Accordingly, it is believed that all pending claims are now in condition for allowance. Applicant therefore respectfully requests an early and favorable reconsideration and allowance of this application. If there are any outstanding issues which might be resolved by an interview or an Examiner's amendment, the Examiner is invited to call Applicant's representative at the telephone number shown below.

To the extent necessary, if any, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted

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